National Climatic Data Center

DATA DOCUMENTATION

FOR

DATA SET 3282 (DSI-3282)

National Solar Radiation Database

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National Climatic Data Center
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1. Abstract: The National Solar Radiation Data Base (NSRDB) is a serially complete collection of hourly values of the three most common measurements of solar radiation (global horizontal, direct normal, and diffuse horizontal) over a period of time adequate to establish means and extremes, and at a number of locations adequate to represent regional solar radiation climates, from 1961-90.

Areas with data include the 50 states of the United States and overseas stations of the US National Weather Service (NWS), US Navy, and US Air Force, including the Caribbean and Pacific. Direct normal data is limited or unavailable in certain areas: The industrial heartland region between Chicago and New York City; most of Alaska; and all island locations. Some data were missing or modeled. A flag indicates these cases.

The times given with all NSRDB data are local standard times. Each solar radiation element is a one-hour value, integrated over the hour preceding its given time. Each meteorological element is an observation made at the given time.

The National Renewable Energy Laboratory (NREL) built the NSRDB, and the data were used to produce the DSI-3282 data set at the National Climatic Data Center (NCDC). DSI-3282 is NCDC's archive format for this data set, featuring daily interleaving of each of the elements specified. Each logical record contains on station's hourly data values for a specific solar radiation element or meteorological element for one day.

2. Element Names and Definitions:

RECORD TYPE

The highest time resolution of data stored in this record. The value is "HLY": Each record contains 24 hourly values (one day).

WBAN NUMBER

The WBAN Number is the station identifier. Assigned by the National Climatic Data Center (NCDC). Range of values = 00000000-00099999.

DATA TYPE CODE

The element, or type of data, stored in this record is indicated by a four character alphanumeric code in this field. Allowed values with their meanings are listed below.

CLHT

DESCRIPTION: Ceiling height
Valid times = 1961 - 1990
The value will appear as 0XXXX
Units = decameters
Range of values = 00000 - 03045
07777 = Unlimited Ceiling Height
08888 = Cirroform
99999 = Missing Data

DPTP

DESCRIPTION: Dew Point Temperature
Valid times = 1961 - 1990

The value will appear as 00XXX
Units = tenths of a degree Celsius (□C)
Range of values = 00000 B 00600 (0.0 - 60.0 □C)
99999 = Missing data

DRAD

DESCRIPTION: Direct Normal Radiation
Direct Normal Radiation is the amount of solar radiation received within a 5.7□ field of view centered on the sun.
Valid times = 1961 - 1990
The value will appear as 0XXXX
Units = watt-hours per square meter (Wh/m^2)
Range of values = 00000 B 01415
99999 = Missing data

ETRH

DESCRIPTION: Extraterrestrial Horizontal Radiation
Extraterrestrial Horizontal Radiation is the amount of solar radiation received on a horizontal surface at the top of the atmosphere.
Valid times = 1961 - 1990
The value will appear as 0XXXX
Units = watt-hours per square meter (Wh/m^2)
Range of values = 00000 - 01415

ETRN

DESCRIPTION: Extraterrestrial Direct Normal Radiation
Extraterrestrial Direct Normal Radiation is the amount of solar radiation received on a surface normal to the sun at the top of the atmosphere.
Valid times = 1961 - 1990
The value will appear as 0XXXX
Units = watt-hours per square meter (Wh/m^2)
Range of values = 00000 - 01415

GRAD

DESCRIPTION: Global Horizontal Radiation
Global Horizontal Radiation is the total amount of direct and diffuse solar radiation received on a horizontal surface.
Valid times = 1961 - 1990
The value will appear as 0XXXX
Units = watt-hours per square meter (Wh/m^2)
Range of values = 00000 - 01415
99999 = Missing data

HZVS

DESCRIPTION: Horizontal Visibility
Valid times = 1961 - 1990
The value will appear as 0XXXX
Units = hectometers
Range of values = 00000 - 01609 (0.0-160.9 km)
07777 = Unlimited Visibility
99999 = Missing Data

PH20

DESCRIPTION: Precipitable Water

Valid times = 1961 - 1990
The value will appear as 00XXX
Units = millimeters
Range of values = 00000 - 00100
99999 = Missing data

PRES

DESCRIPTION: Atmospheric Pressure
Valid times = 1961 - 1990
The value will appear as 0XXXX
Units = millibars
Range of values = 00700 - 01100
99999 = Missing Data

PWX1

DESCRIPTION: Present Weather for first five weather elements
Valid times = 1961 - 1990
The values will appear as XXXXX as follows:

XXXXX *** Observation Indicator
where:

X = 0 Weather Observations Made
= 9 Weather Observations not made or missing

X**X**XXX *** Occurrence of Thunderstorm, Tornado, Squall
where:

X = 0 Thunderstorm - lightning and thunder. Wind gust < 25.7 m/s, and hail, if any, < 1.9 cm diameter.
= 1 Heavy or severe thunderstorm frequent intense lightning and thunder. Wind gust > 25.7 m/s and hail, if any, >= 1.9 cm diameter.
= 2 Report of tornado or water spout
= 4 Moderate squall - Sudden increase of wind speed by at least 8.2 m/s, reaching 11.3 m/s or more and lasting for at least one minute.
= 6 Water spout (began Jan 1984)
= 7 Funnel cloud (began Jan 1984)
= 8 Tornado (began Jan 1984)
= 9 None if Observation Indicator equals 0, else unknown or missing if Observation Indicator equals 9.

XX**X**XX *** Rain, Rain Showers, Freezing Rain
where:

X = 0 Light rain
= 1 Moderate rain
= 2 Heavy rain
= 3 Light rain showers
= 4 Moderate rain showers
= 5 Heavy rain showers
= 6 Light freezing rain
= 7 Moderate freezing rain
= 8 Heavy freezing rain

= 9 None if Observation Indicator equals 0, else unknown or missing if Observation Indicator equals 9.

Note: Light = up to 0.25 cm per hour
Moderate = 0.25 to 0.76 cm per hour
Heavy = more than 0.76 cm per hour

XXX**X**X *** Rain Squalls, Drizzle, Freezing Drizzle
where:

X = 0 Light rain squalls
= 1 Moderate rain squalls
= 3 Light drizzle
= 4 Moderate drizzle
= 5 Heavy drizzle
= 6 Light freezing drizzle
= 7 Moderate freezing drizzle
= 8 Heavy freezing drizzle
= 9 None if Observation Indicator equals 0, else unknown or missing if Observations Indicator equals 9.

Notes: When drizzle or freezing drizzle occurs with other weather phenomena:
Light = up to 0.025 cm per hour
Moderate = 0.025 to 0.051 cm per hour
Heavy = More than 0.051 cm per hour

When drizzle or freezing drizzle occurs alone:
Light = Visibility 1 km or greater
Moderate = Visibility 0.5 B 1.0 km
Heavy = Visibility 0.5 km or less

XXXX**X** *** Snow, Snow Pellets, Ice Crystals
where:

X = 0 Light snow
= 1 Moderate snow
= 2 Heavy snow
= 3 Light snow pellets
= 4 Moderate snow pellets
= 5 Heavy snow pellets
= 6 Light ice crystals (ends March 1963)
= 7 Moderate ice crystals
= 8 Heavy ice crystals (ends March 1963)
= 9 None if Observation Indicator equals 0, else unknown or missing if Observation Indicator equals 9.

Notes: Beginning Apr 63, any occurrence of ice crystals is recorded as a 7.

PWX2

DESCRIPTION: Present Weather for second five weather elements
Valid times: 1961 - 1990
The values will appear as XXXXX as follows:

XXXXX *** Snow Showers, Snow Squalls
where:

X = 0 Light snow showers
= 1 Moderate snow showers
= 2 Heavy snow showers
= 3 Light snow squall
= 4 Moderate snow squall
= 5 Heavy snow squall
= 9 None if Observation Indicator equals 0, else unknown or missing if Observation Indicator equals 9.

X**X**XXX *** Sleet, Sleet Showers, Hail
where:

X = 0 Light ice pellet showers
= 1 Moderate ice pellet showers
= 2 Heavy ice pellet showers
= 3 Light hail (see note below)
= 4 Hail
= 9 None if Observation Indicator = 0, unknown or missing if Observation Indicator = 9.

Notes: Prior to April 1970, ice pellets were coded as sleet. Beginning April 1970, sleet and small hail were redefined as ice pellets and are coded as 0, 1 or 2.

XX**X**XX *** Fog, Blowing dust, Blowing Sand
where:

X = 0 Fog
= 1 Ice fog
= 2 Ground fog
= 3 Blowing dust
= 4 Blowing sand
= 5 Heavy fog
= 6 Glaze (began 1984)
= 7 Heavy ice fog (began 1984)
= 8 Heavy ground fog (began 1984)
= 9 None if Observation Indicator = 0, else unknown or missing if Observation Indicator = 9.

Notes: The above values are recorded only when visibility is less than 11 km.

XXX**X**X *** Smoke, Haze, Smoke and Haze, Blowing Snow, Blowing Spray, Dust
where:

X = 0 Smoke
= 1 Haze
= 2 Smoke and haze
= 3 Dust
= 4 Blowing snow

= 5 Blowing spray
= 6 Dust storm (begin 1984)
= 7 Volcanic ash
= 9 None if Observation Indicator = 0, unknown or missing if Observation Indicator = 9.

Notes: The above values are recorded only when visibility is less than 11 km.

XXXX**X** *** Ice Pellets
where:

X = 0 Light ice pellets
= 1 Moderate ice pellets
= 2 Heavy ice pellets
= 9 None if Observation Indicator = 9, unknown or missing if Observation Indicator = 9.

RHUM

DESCRIPTION: Relative Humidity
Valid times = 1961 - 1990
The value will appear as 00XXX
Units = percent
Range of values = 00000 - 00100
99999 = Missing data

SNOW

DESCRIPTION: Snow Depth and Days Since Last Snowfall
Valid times = 1961 - 1990
The values will appear as XXXYY

XXX = Snow Depth
Units = centimeters
Range of values = 000 - 900
999 = Missing data

YY = Days since last snowfall
Range of values = 00 - 88
88 = 88 or greater days
99 = Missing data

SRAD

DESCRIPTION: Diffuse Horizontal Radiation
Diffuse Horizontal Radiation is the amount of solar radiation received on a horizontal surface from the sky, excluding the solar disk.
Valid times = 1961 - 1990
The value will appear as 0XXXX
Units = watt-hours per meter squared (Wh/m^2)
Range of values: 00000 B 01415 Wh/m^2
99999 = Missing data

TMPD

DESCRIPTION: Dry Bulb Air Temperature
Valid times = 1961 - 1990
The value will appear as 00XXX
Units = tenths of a degree Celsius (□C)

Range of values = 00000 B 00600 (0.0 B 60.0 □C)
99999 = Missing data

TURB

DESCRIPTION: Broadband Aerosol Optical Depth (broadband turbidity)
Valid times = 1961 - 1990
The value will appear as 00XXX
Units = thousandths
Range of values = 00000 B 00900 (0.000 B 0.900)
99999 = Missing data

TSKC

DESCRIPTION: Total sky cover and Opaque Sky Cover
Valid times = 1961 - 1990
The values will appear as 0XXYY

0XX = Total sky cover
Total sky cover is the amount of the sky dome covered by clouds.
Units = tenths
Range of Values of XX = 000 - 010 (0.0 B 1.0)
999 = Missing data

YY = Opaque sky cover
Opaque sky cover is the amount of the sky dome covered by clouds that prevent observing the sky or higher cloud layers.
Units = tenths
Range of Values of YY = 00 - 10 (0.0 B 1.0)
99 = Missing data

WIND

DESCRIPTION: Wind Direction and Wind Speed
Valid times = 1961 - 1990
The value will appear as XXYYY

XX = Wind direction
Direction is the direction from which the wind is blowing.
Units = tens of degrees

Range of values = 00 B 36 (000 - 360□)
99 = Missing data

YYY = Wind speed
Units = tenths of meters per second (m/s)
Range of values = 000 - 990 (0.0 - 99.0 m/s)
999 = Missing data

MEASUREMENT UNITS CODE

Measurement units used for the DATA VALUE and, where applicable, the implied decimal point location. Allowed values with their meanings are listed below. Usually there is one value and one measurement unit; the two exceptions are noted. The field DATA TYPE CODE conveys this information and more, so MEASUREMENT UNITS CODE is a somewhat redundant field.

CD	Centimeters
DM	Decameters, or tens of degrees and tenths of meters per second[H]
KM	Kilometers to tenths (i.e. 111 = 11.1 km)
MB	Millibars
MM	Millimeters
NA	Not applicable[I]
P	Percent
TC	Degrees Celsius to tenths (i.e. 123 = 12.3 □C)
WM	Watt-hours per square meter

[H] Either (1) the units are decameters (123 = 1230 m) or (2) DATA VALUE consists of two values with two units, which are tens of degrees (18 = 180□) and tenths of meters per second (123 = 12.3 m/s), respectively.

[I] Either DATA VALUE (1) is a unit less quantity, or (2) is a code that translates to five different values, each with a different unit..

YEAR

The year of the record. Range of values = 1961 - 1990.

MONTH

The month of the record. Range of values = 01 - 12.

SOURCE CODE 1

Constant, reserved for future applications. The value is 1.

SOURCE CODE 2

Constant, reserved for future applications. The value is 1.

DAY

The day of the record. Range of values = 01 - 31.

NUM-VALUES

The number of data groups that follow, beginning with the next element, TIME OF VALUE, which is the first element in each data group. For these data, NUM-VALUES is the number of hourly DATA

VALUES available for the calendar day given by YEAR, MONTH and DAY.

TIME OF VALUE

TIME OF VALUE contains the hour and minute associated with the DATA VALUE. Range of values = 0000 - 2300. The hour is the leftmost two digits and the minute is the rightmost two digits. However, minutes are always 00. 0000 = Midnight.

SIGN OF DATA VALUE

The sign of the DATA VALUE. A minus sign is used for negative values. A blank is used for zero or positive values.

DATA VALUE

DATA VALUE is always a five-digit integer that can represent one value, or five values, for the element given by the DATA TYPE CODE field. DATA VALUE=s arithmetic sign, implied decimal point location, and measurement units are given by SIGN OF DATA VALUE and DATA TYPE CODE. DATA VALUE is associated with the time given by YEAR, MONTH, DAY, and TIME OF VALUE.

Note: For solar radiation elements, DATA VALUE represents an amount of solar radiation integrated over the hour ending at TIME OF VALUE; for meteorological elements, this value is based on observations made at TIME OF VALUE.

FLAG 1

Data Source FLAG. Values appear as X, where

For solar radiation data:

X = A Post-1976 measured solar radiation data as received from NCDC or other source.
= B Same as A except the global horizontal data underwent a calibration correction
= C Pre-1976 measured global horizontal data (direct and diffuse were not measured before 1976), adjusted from solar to local time, usually with a calibration correction
= D Data derived from the other two elements of solar radiation using the relation Kt = Kn + Kd, where Kt is global radiation, Kn is direct normal radiation, and Kd is diffuse horizontal radiation
= E Modeled solar radiation data using inputs of *observed* sky cover (cloud amount) and aerosol optical depths derived from direct normal data collected at the same location
= F Modeled solar radiation using *interpolated* sky cover and aerosol optical depths derived from direct normal data collected at the same location
= G Modeled solar radiation data using *observed* sky cover and aerosol optical depths *estimated* from geographical relationships
= H Modeled solar radiation data using *interpolated* sky cover and *estimated* aerosol optical depths
= ? Source does not fit any of the above categories. Used for nighttime values, calculated extraterrestrial values, and missing data

For meteorological data:

X = A Data as received from NCDC, converted to Standard International units
= B Linearly interpolated to fill short data gaps
= C Non-linearly interpolated to fill data gaps from 6 to 47 hours in length
= D Long data gaps from 48 hours to one year filled from other years
= E Modeled or estimated, except: precipitable water, calculated from radiosonde data; and aerosol optical depth, calculated from direct normal data
= F Precipitable water, calculated from surface vapor pressure; aerosol optical depth, estimated from geographic correlations
= ? Source does not fit any of the above. Used mostly for missing data

FLAG 2

Data Uncertainty Flag. Values appear as X, where

For solar radiation data:

X = 1 0B 2 % uncertainty range
= 2 2B 4 A
= 3 4B 6 A
= 4 6B 9 A
= 5 9B13 A
= 6 13-18 A
= 7 18-25 A
= 8 25-35 A
= 9 35-50 A
= 0 Not applicable

For meteorological data:

X = 1 Not used
= 2 Not used
= 3 Not used
= 4 Not used
= 5 Not used
= 6 Not used
= 7 Uncertainty consistent with NWS practices and the instrument or observation used to obtain the data
= 8 Greater uncertainty than 7 because values were interpolated or estimated
= 9 Greater uncertainty than 8 or unknown
= 0 Not definable

3. Start Date: 19610101

4. Stop Date: 19901231

5. Coverage: Global coverage, non US stations primarily by military observers.

a. Southernmost Latitude: 90S
b. Northernmost Latitude: 90N
c. Westernmost Longitude: 180W
d. Easternmost Longitude: 180E

6. How to Order Data:

Ask NCDC's Climate Services about the cost of obtaining this data set.
Phone: 828-271-4800
FAX: 828-271-4876
E-mail: **NCDC.Orders@noaa.gov**

7. Archiving Data Center:

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, NC 28801-5001
Phone: (828) 271-4800.

8. Technical Contact:

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, NC 28801-5001
Phone: (828) 271-4800.

9. Known Uncorrected Problems:

A. Bad Meteorological Data

NCDC's quality control procedures detect and flag data that fail internal consistency checks or exceed preselected climatological limits. When such data are detected, edited values are normally inserted immediately after the bad data. During the data base production, due to an oversight the last value in the DSI-3280 and DSI-3210 files for a given hour and element was always used. Normally this value would have been a good original value or an edited value. However, there were cases when bad data was not followed by an edited value; then the bad data were inadvertently used. When this oversight was discovered, it was too late to effect a correction with the time and resources remaining. Only two instances have been discovered when this problem affected the estimation of solar radiation data, but it is likely that others exist. Abnormally large snow depths (300 to 900 inches) were found during one month and one year for Kansas City, Missouri, and San Antonio, Texas. These two problems were corrected, but they led to the realization that similar problems of lesser magnitude could go undetected. Although bad meteorological data may be infrequent, and may be mostly insignificant, exceptions undoubtedly exist.

B. Using Data from Other Years to Replace Missing Meteorological Data

Special means were employed to maintain serially complete files of solar radiation data when long segments (more than 47 hours) of missing meteorological data were found. The majority of these occurred at stations that were not operated during the evenings or on weekends. However, sometimes

a station would be shut down for several weeks or even longer. When these situations occurred, the gaps in the data were filled with data from other years, for the same days of the year. Short gaps in the data record, for those meteorological elements needed to perform model estimates of solar radiation, were filled by linear interpolation between data points on each side of the gap. Interpolated values were rounded to the same number of significant figures reported for the measured/ observed data. What was considered a short gap depended on the known rate of change of the element. Sky cover, for example, was linearly interpolated over gaps as long as five hours. Based on an autocorrelation analysis that is described in Volume 2 of the NSRDB documentation, total precipitable water was linearly interpolated over gaps as long as 60 hours (five missed soundings). Interpolation between individual soundings was used to obtain hourly precipitable water data. For longer gaps in radiosonde data, calculations of precipitable water were made using surface vapor pressure derived from surface temperature, relative humidity, and atmospheric pressure. When the surface data were also missing, long gap methods were applied to obtain the required data. Long gaps in the meteorological data (sky cover, temperature, and relative humidity) were subdivided into two categories: 6-hour to 47-hour gaps and 48-hour to one-year gaps. For gaps 6 to 47 hours in length, data from adjacent time periods for identical periods (e.g., beginning at 0600 and ending at 2300) were selected to fill the gap. These segments of data were adjusted to match the end-point values of the gap. For gaps of 48 hours to one year, data from other years for the same time periods were selected to fill the gap. The selection was based on finding a year for which the data before and after the period of the gap had the “best match” with data before and after the actual gap. “Best match” was determined by characterizing three time slices for several days adjacent to the actual gap and comparing them to a corresponding period of time in candidate years. The larger the gap, the greater the number of days included in the characterization, up to four weeks. No effort was made to fill gaps in snow depth or present weather data. These discontinuous weather events did not lend themselves to interpolation or substitution methods. When missing, snow depth was set to zero. Only those elements required to provide input to the METSTAT model were replaced. These elements include total and opaque sky cover, dry bulb temperature, relative humidity, and atmospheric pressure (the last three were used to estimate precipitable water). Because all of the data replacement processes were done one element at a time, it is possible that different elements may have been selected from different years. Therefore, it is possible that this replacement process produced some inconsistencies among the meteorological elements. The impact on model estimates of solar radiation, however, should be minor, because total and opaque sky cover were always checked for consistency, and errors in precipitable water have a relatively small effect on solar radiation estimates. (To mitigate this problem, the station notes in Appendix B of Users? Manual National Solar Radiation Data Base 1961-1990 (NSRDB-Volume-1) contains footnotes that identify the stations for which this replacement method was invoked.)

C. Present Weather Data

For some stations and years, the first field position in the present weather data was inadvertently set to zero (0), which is one of two valid values, for all hours. Zero means that observations were made. The other possible value was a nine (9), indicating missing data or no observations made. For these cases, the first field position is therefore unreliable. This did not affect the model estimates of solar radiation because no attempt was made to replace missing present weather data. (Interpolation cannot be used to estimate the

occurrence of discontinuous events such as rainfall.) This problem should be of concern primarily to those using present weather for other applications.

D. Incomplete Replacement of Missing Meteorological Data

Some NWS stations limit their operations to daylight hours and, in some cases, only to part of the day. When data for hours at the beginning and ending of the sun-up period were missing for these stations, the meteorological elements needed for model estimates of solar radiation were filled-in through an extrapolation process, but only to sunrise and sunset. No reasonable method of filling in nighttime data could be devised. Therefore, users who are concerned with nighttime conditions will have to avoid these stations or devise their own replacement scheme. Also, no replacement of missing data was attempted for discontinuous elements or elements not required for model estimates of solar radiation. This includes dew point temperature, wind direction and speed, horizontal visibility, ceiling height, present weather, snow depth, and number of days since last snowfall.

E. Lack of Aerosol Optical Depth Data

Aerosol optical depths were estimated from direct normal solar radiation measurements. Direct normal data were especially sparse for three regions: Most of Alaska; all island locations, such as Hawaii, Guam, and Puerto Rico; and the industrial heartland of the United States from Chicago to New York City. For example, during the period from 1961 to 1990, from all of the states of Illinois, Indiana, Michigan, Ohio, Pennsylvania, and New York, direct normal data are available only from Pittsburgh, Pennsylvania and Albany, New York. Furthermore, Pittsburgh data were sparse and of questionable quality. Therefore, the model estimates of direct normal and diffuse horizontal solar radiation for these regions must be considered suspect, perhaps even more suspect than is indicated by the assigned uncertainty values. Fortunately, errors in aerosol optical depth have a relatively small effect on global horizontal values.

F. NWS Solar Radiation Measurements from 1981 to 1985

From January 1981 through October 1985, the data collected by NOAA-NWS was not processed or quality controlled. Although a quality assessment of this data was attempted during data base production, some defects are difficult to detect. One problem of particular concern is errors in time. Errors in time large enough to cause shifts of daytime data to nighttime hours were easy to detect; the quality assessment software detected measured data with gross errors for all years. However, smaller shifts in time, of one or two hours or partial hours, could have gone undetected by the software. Therefore, users are advised to treat measured solar radiation data from NWS stations for the period from 1981 to 1985 with extra caution.

G. Missing SOLMET Data

The quality flags for some of the 26 SOLMET stations indicate that global horizontal data were modeled during periods of time when measured data may have been expected. This is particularly true for stations in the western United States from about 1968 to 1975. Although the serial plots of 15-day averages (solar noon values) found in SOLMET Volume 2 (1979) indicate that data were available, the extraction of hourly values from the strip chart records was sometimes not completed. The station notes SOLMET Volume 1 (1978)

identify the periods of time when the global horizontal data were modeled. These values were estimated with the METSTAT model.

10. Quality Statement: Quality of the National Solar Radiation Data Base is considered quite good. All observations have received some form of quality control measures depending on the agency and the years of collection. During the early years this was almost entirely a manual effort. As more sophisticated techniques of processing were introduced, the quality control procedures were also improved. Generally, quality has improved throughout the period of record. Beginning with the data for January 1984, the surface airways hourly observations were processed through a completely revised system. Relying heavily on new computer editing procedures, data are subjected to internal consistency checks, compared against climatological limits. Therefore, the data from 1985-1990 had the best quality control.

11. Essential Companion Datasets: None.

12. References:

NSRDB Volume 1 (1961-1990) National Solar Radiation Data Base User Manual, National Renewable Energy Laboratory, 1617 Cole Blvd., Golden, CO 80401